Solar Hot Water Systems

Heating domestic hot water (DHW) is the second highest energy cost in a typical household. An average family of four, using an electric hot water heater and paying nine cents per kilowatt-hour (kWh), will spend about $400 a year on hot water. A solar DHW system can economically provide two-thirds or more of this energy at a cost equivalent to six to eight cents per kWh.

Modern solar water heating technology has been in use for over 20 years and is a highly reliable technology with more than 100,000 installations in the United States. During the first half of the 1980's, federal and state tax credits for solar systems spurred research and development efforts. Though these credits are not presently available, the research efforts have paid off in lower-cost, more efficient systems.

Because of Vermont's cloudy winter climate, it is not economical to install a solar DHW system that can supply 100 percent of the hot water load year-round. Systems are typically designed to meet 100 percent of the load in the summer and have a year-round solar "fraction" of about 65 percent. This means solar DHW systems are always designed as preheat systems with back-up electric, propane, oil or wood systems that can supply extra heat when needed.

Modern solar water heating technology .... is highly reliable.

Solar water heating systems can also be used for providing some of a building's space heat. However, because a building's highest heating load occurs during our worst solar months (November, December and January), active space heating is cost-effective only in limited circumstances.

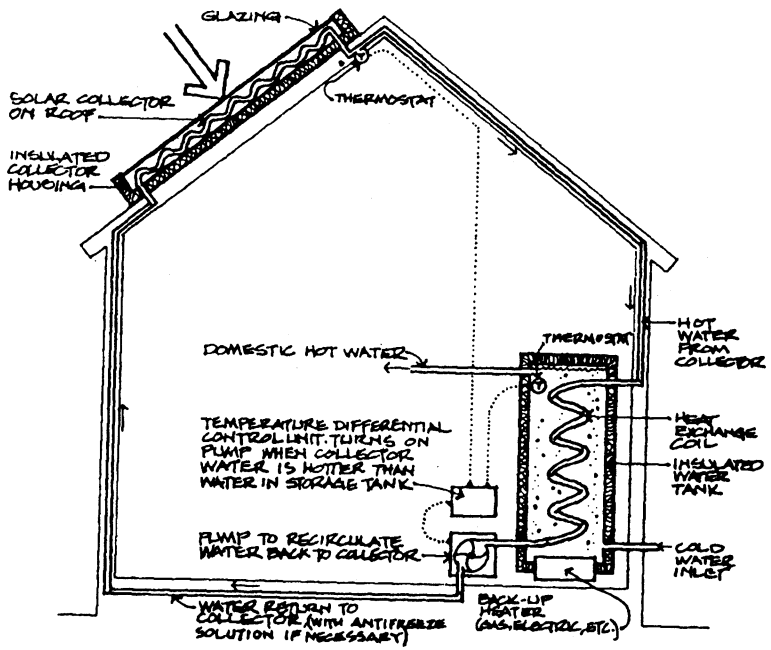
How Do They Work?

There are many types of solar DHW systems in use throughout the world. These range from a simple black water tank left in the sun (a passive *batch heater*) to sophisticated collector systems that are computer controlled.

In Vermont, with its freezing climate, the most widely used system is called a *closed-loop antifreeze system.* Such a system has three major components: the solar collectors, a storage tank and a heat exchanger. A non-toxic antifreeze solution (propylene glycol) is typically used to transfer heat from the collectors to the storage tank. The function of the *heat exchanger* is to transfer the solar heat from the antifreeze solution to the domestic water without letting the two fluids come in contact. Solar tanks may be bought with an "internal" heat exchanger that is immersed in the tank water or with an "external" heat exchanger that is attached to the outside of a standard storage tank.

Most systems use *flat-plate collectors* to absorb solar energy. A collector is usually a 4' x 8' or 4' x 10' box that contains an *absorber plate.* The absorber is a metal plate coated with a special black *selective surface* that increases solar absorption. The plate transfers the solar heat to a series of tubes through which the antifreeze solution flows. The absorber is insulated on the back and sides and a piece of tempered, low-iron glass is used as the cover glazing.

The optimum mounting angle for the collectors at Vermont's latitude is 45 degrees above horizontal for year-round solar gain. The angle may be as high as 60 degrees with very little performance drop, but should never be lower than 30 degrees as this will cause summer overheating and will not shed winter snow. Collectors are typically mounted on the house



Solar Water Heater

roof, but may also be ground mounted for aesthetic reasons or better solar access. A typical home system will consist of two 4′ x 8′ or 4′ x 10′ collectors.

Active vs. Passive Systems

An *active system* will use a controller and circulator to move heat from the collectors to the storage tank. A *passive system* will rely on natural thermosyphoning or the "geyser" effect (like a coffee percolator boiling) to circulate the heat transfer fluid without a circulator.

The operation of an active system is quite simple. A *differential controller* monitors the temperature of the collectors and the storage tank. Whenever the collectors are hotter than the tank, the controller energizes a low-

wattage *circulator* to move the solar-heated solution from the absorber plates. Heat is then extracted from the fluid by a heat exchanger at the storage tank.

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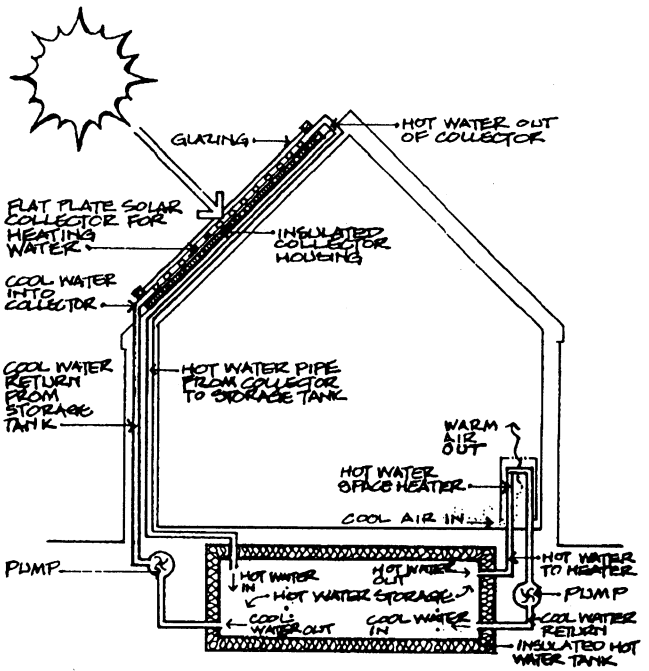
Preheated water in the solar tank is then fed to a conventional water heater for supplemental heating if necessary. Solar DHW systems may be used as a preheat source for any type of hot water system including instantaneous heaters.

The operation of a passive thermosyphon system is essentially the same except the antifreeze fluid circulates by natural convection. When the collectors are heated, the hot fluid rises because it is lighter and starts thermosyphoning. For such a system to work, however, the storage tank must be above the collectors and there must be minimal flow restriction (such as a long pipe run) that would stop the natural thermosyphon effect. Passive systems that use the geysereffect are just the opposite; they must have the collectors above the storage tank.

Because of their reliability, superior efficiency compared to passive systems, and because there are no restrictions on collectors location, active systems are most commonly installed in Vermont. Regardless whether the choice is an active or passive system, the most important point is to design and install the system according to manufacturer's instructions. The best equipment will fail to live up to its potential if incorrectly installed.



Solar Space Heating

Can Solar Heat My Home?

Flat-plate collectors can also be used to provide space heat in addition to domestic hot water. These systems typically have several hundred square feet of collector area rather than the 60 to 100 square feet needed for DHW heating. Separate heat exchangers are used to provide heat to the DHW tank and to the house heating system. Homes that use *radiant floor heating* with underfloor tubing are ideally suited for active solar because they operate at a low temperature and the thermal mass of the floor can be used to store heat.

A major design consideration in such a hybrid system is what to do with excess heat generated during the summer months. A solar system will have its peak output during June, July and August when much of the heat

must be dissipated somewhere other than the hot water tank or the house. One solution is to use the extra energy for pool or spa heating. If all the energy of such a system can be used year-round, then these hybrid systems can be cost-effective.

While many solar DHW systems can be installed by the homeowner, designing and installing large hybrid heating systems is a complex task that should be left to experienced contractors.

Exploring Your Options

Here are a few items that will help you understand the cost and benefits of investing in a solar hot water system:

- Have you installed hot water conservation devices such as low-flow shower heads and faucet aerators that will reduce your hot water consumption?
- Are your hot water tank and piping insulated? Is there a heat trap on the tank?
- Is there a south-facing space on the roof or ground that is within 30 degrees of true south (195 degrees magnetic) that is large enough for two 4′ x 8′ collectors?
- Is the site unshaded between 9 a.m. and 3 p.m.?
- Are the collector location and mounting angle acceptable in terms of aesthetics?

If the answer to all these questions is yes, then you have a suitable site for solar water heating. You should then contact solar DHW dealers to request information on their systems. The information should contain system specifications, cost and performance information. Most dealers will be willing to prepare a solar savings analysis that is based on your hot water consumption (gallons per day) and your current cost of heating water. Based on this information you should be able to determine which systems look most cost-effective.

The final and most important step is to ask for a firm installation price quote from the dealer. The hardware costs of most solar systems are fairly similar, but the installation costs can vary dramatically. Only by comparing the installed cost of various systems (along with their maintenance costs) can you determine which is the most cost-effective. This step will often entail a detailed site visit by the installer for which there may be a charge.